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APPLICATION OF GEOSPATIAL ANALYSIS AND AUGMENTED REALITY VISUALIZATION IN INDOOR ADVERTISING

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ABSTRACT

In recent years, capabilities of modern smartphones offer the potential to design tools that support new form of marketing, advertising and providing smarter business systems. The features and ubiquity of mobile technologies provide opportunities for developing new experiences that support a pervasive advertising. The use of ubiquitous computing technologies for advertising purposes presents huge opportunities and challenges for our future and bring new concept as an Ubi-Advertising. Indoor Advertising reaches consumers from an uncluttered, captive, eye-level vantage point, making it unavoidable. In this contribution, a concept to estimate installation's location of indoor advertising billboards and signs in 3D visualization space has been introduced. This study proposes a new framework to apply capabilities of Ubiquitous Geographic Information Systems (UbiGIS) and spatio–temporal modeling to determine the best location for installing advertising billboards and signs in indoor environments. For this purpose, first, it used 3D visibility analysis for modelling 3D environment. After identifying suitable location, the result was used to create a location-based service (LBS). Then, application software was developed based on Augmented Reality (AR) technology for visualizing advertisements in the effective way. AR provides additional information about the ads and creates interactive content. Milad-e-Noor shopping center in Tehran city was selected and the model was implemented in this area. The results prove the merit of this research.

Keywords: Ubiquitous GIS, Smart cities, Spatio–temporal modeling, Indoor advertising, Augmented reality.

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Contribution/ Originality

This study originates new executive framework for advertising in indoor environments and creating efficient advertising. The meaning of the term "efficient" has been specified by integrating geospatial analysis and ubiquitous computing capabilities. This article uses an Augmented Reality technology as a powerful user-interface, which is developed in an Android OS platform.

1. INTRODUCTION

The completion between businesses to outwit each other vis-à-vis dominate the markets with their products consistently see them taking aggressive form of marketing. Thus, each company

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tries to increase their products sales by adopting methods that will keep them on top. Advertisement is one of the most important ways of marketing that tends attracts customers. Advertisement includes TV, newspaper Ads, posters, bulletins, wall murals, city billboards and etc (Kotler and Keller, 2009). formulated a standard definition of advertising, "as any paid form of non-personal presentation and promotion of ideas, goods, or services by an identified sponsor". Accordingly, the task of advertising is to systematically plan, design, coordinate, and control all communicational activities of an organization with respect to relevant recipient groups in order to contribute to the marketing objectives (Müller *et al.*, 2011). According to official report of Outdoor Advertising Association of America (OAAA) the advertising marketing size is more than 5.6 billion dollars yearly. Today, out of home advertising is a dynamic mix of billboards, digital displays, transit, street furniture, cinema, and place-based media that surround and immerse consumers during the 70 percent of the day they spend away from home.

One of the most important issues about advertising billboards is their location of indoor spaces like airports, night club, commercial complexes, shopping centers, business organizations etc. In the past, some research attempted to classify billboards and to clarify their structures (Reyes and Bernadette, 2009), reviewing the methods to establish advertising billboards, (Hernández-Ávila *et al.*, 2007) studied advertisement quality especially on gender bias and public health concern. There is a growing need for automated data acquisition and storage systems to enhance the advertising sign-inventory process (Overturf, 2002). Thus, modeling with GIS for localization of customers using advertising billboards and offers recommendations on when and how to use outdoor advertising based on unique business market characteristics, industrial promotional objectives and business product classification (Lichtenthal *et al.*, 2006). the use of visible and spatial methods for localization virtual advertisement in football match (Aldershoff and Gevers, 2004).

On the other hand, an ubiquitous-based method provides an environment for efficient services in anyplace, anytime, via any network, and any condition (Krumm, 2010). Ubiquitous computing is considered as a new generation in IT-based techniques which can give more freedom for the architecture in which information processing has been thoroughly integrated into everyday objects and activities (Jiang and Yao, 2006; Sadeghi-Niaraki *et al.*, 2011). An ubiquitous system can create an intelligent environment that any extracted information and context as well as, the data stored in database have been utilized in a smart way (Weiser, 1993). In GIS environment, Augmented Reality (AR) is interface with a computer system, which is able to overlay information on top of what a user sees in order to improve ability to carry out a task. Such a system could also access related manuals simply by selecting the corresponding item in the field of view with a pointing device. The meaning of augmented reality (AR) can be derived from the name itself: a reality that is augmented (enriched) by some sort of digital media. The process takes place in real time. It is interactive. The computer-generated elements are strongly connected with fragments of objective physical reality and have some specific reactions to them (Seo and Lee, 2013). AR is a live, direct or indirect, view of a physical world environment in which the elements are augmented by computer-generated sensory input such as sound, video, or graphics data (Geroimenko, 2012). Thus, AR is considered to be an excellent user interface to a 3D information space embedded within physical reality (Daponte *et al*., 2014). This has made possible for AR to be widely used in various application scenarios such as education and learning, table-top, medical AR, interaction, and collaboration (Koch *et al*., 2014). Mobile augmented reality and image recognition platform enables advertisers to reach consumers via outdoor ads, billboards, magazine, and newspaper.

Geographic Information Systems (GIS) is useful for manipulating spatial aspects of selecting suitable sites, due to its ability to bring together many diverse and complex factors to facilitate development and administrative decisions (Sadeghi-Niaraki *et al*., 2011). There is a problem on how to locate billboards, and design its size and shape. Billboard installation is based on a traditional method. GIS has a great potential to managing this problem. GIS capabilities can be applied in two steps: find the best place to install advertisement platform, and integrating with ubiquitous computing to create a better visualization for ads content. This research has developed an ubiquitous based advertising method to perform a smart site selection for installing billboards and advertising signs. Thus, Multi-Criteria Decision Making (MCDM) and geospatial analyses was used, along with Augmented Reality which is based on service that visualized billboards and signs in the effective way were utilized.

2. MATERIALS AND METHODS

In order to implement this research, spatio-temporal modelling of pedestrian in indoor environment by video tracking was adopted using criterion such as density, speed and direction. Each criterion created into a GIS. Equally, weighting criteria implemented by Multi-Criteria Decision Making was adopted. The final created map shows potential of pedestrian and customer's attention to advertisement display. The potential map is used for 3D visibility analysis and assigning values to all space. After identifying the best 3D location for installing billboards and other advertisement forms, in the next step AR services has been developed.

3. CASE STUDY

Tehran city is the capital of Iran. With a population around 8.3 million and surpassing 14 million in the wider metropolitan area, Tehran is Iran's largest city and urban area, and the largest city in Western Asia (Tehran, n.d). Tehran is ranked 29th in the world by the population of its metropolitan area (Tehran, n.d). Milad-e-Noor commercial complex in Tehran city was selected as the case study area of this research. Due to the commercial nature and a number of administrative organizations, Milad-e-Noor is one of the most heavily traveled areas that a large number of citizens are going to this area for administrative and shopping tasks every day (Figure 1).

The observed counts carried out on installment in the area (three timeframes): morning, afternoon and evening, shows that the average number of people crossing the entrance door and the corridor are averagely 150 and 200 per hour, respectively. Therefore, this commercial and administrative area is one of the most heavily accessed complexes in Tehran city that have the potential for indoor advertising. Based on population density of several parts of the study area and coupled with the social traits, personal characteristics in different location, and the viewing angles, the area was divided to several parts (Figure 2):

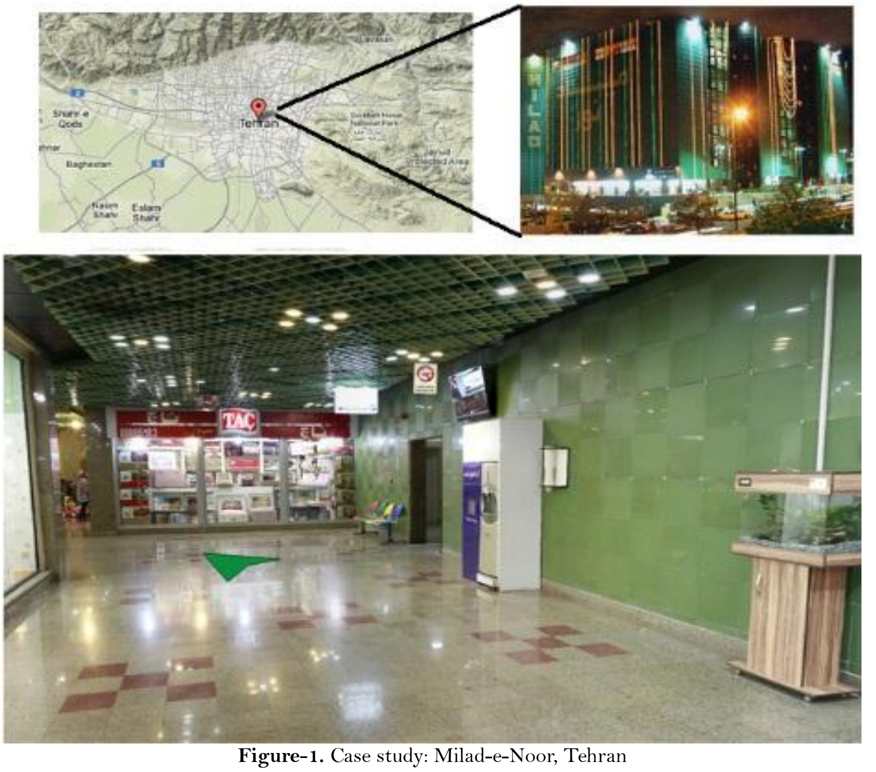


Figure-1. Case study: Milad-e-Noor, Tehran

Corridors, Elevators output area, Escalator and stairs output area and Entrance doors area.

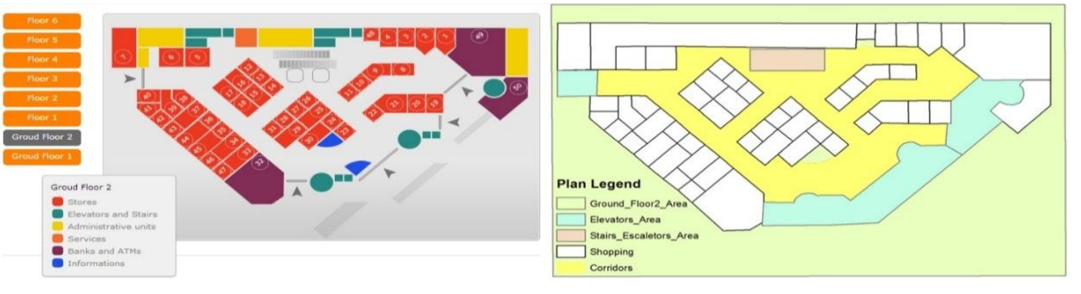


Figure-2. Plan of ground floor 2 of Milad-e-Noor shopping center

4. MODELLING METHOD

Figure 3 shows the methodology used in this research. The method used for modeling includes several sections such as data preparation section, criteria weighting part, Analytic Hierarchy Process (AHP) and model creation section, grid base process, LV analysis, optimization section and Augmented Reality service. In the first step as data preparation we created all needed layers such as: elevators area, stairs and escalators area, shopping footprints, corridors shape file. We chose ground floor 2 for digitizing all area. In criteria weighting section 3 layers will be weighted. The result of this section will be used to 3D visibility analysis. In the last stage has been created an augmented reality services that provided interactive visualization of Ads content.

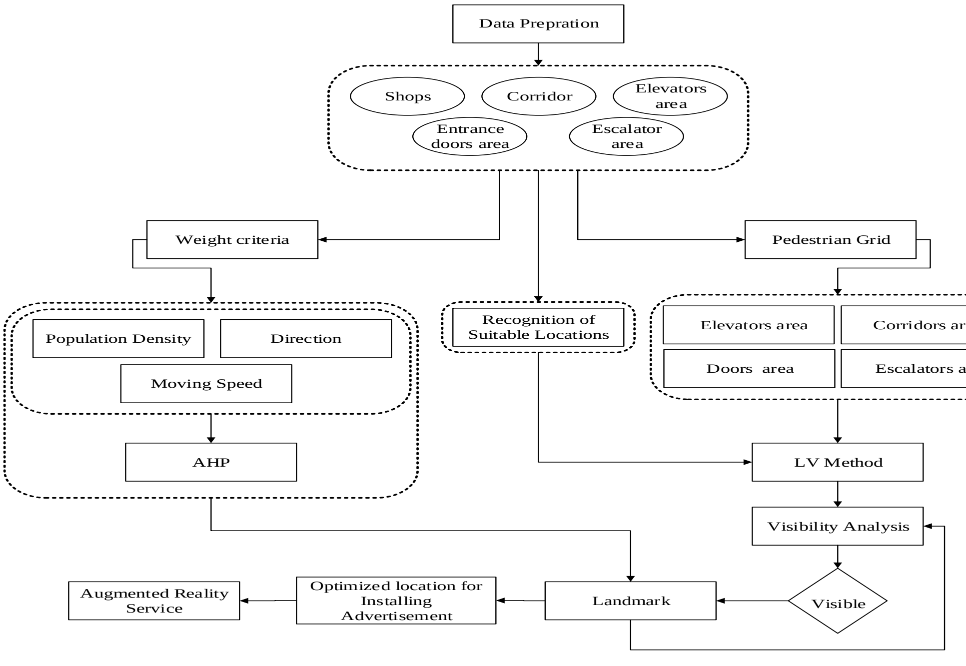


Figure-3. Flowchart of the model

4.1. Pedestrian Grid

In order to check the visibility scope, the study area has laid out in a regular grid. Population density and moving direction distances among different parts are variable in several areas. In order to specify grid distances, following pattern has been used. Population density is different in every area. In this scale the least possible space for each person in every area will be different (Table 1). For example in corridors area, we proposed a 1*1 m grid, which reflected human body ellipsoid. In high density area such as elevators exit and entrances, used a 0.5*0.5m grid.

Table-1. Grid distance

Type of area	Grid distance	
	Width	**Length**
Corridor	1	1
Elevators area	0.5	0.5
Entrance of per floor	0.5	0.5
Escalator and stairs area	0.5	0.5

4.2. Criteria Weighting

The microscopic movement of 220 pedestrians and customers was investigated in a covert, video-based observational study of Milad-e-Noor environments close to the city centers of Tehran, Iran. Age, gender, level of mobility, group size, time of day, and location were found to have significant effects on movement preferences across the range of locations studied (Willis *et al.*, 2004). Parts of Exit elevator are different in importance with corridors. Considering several criteria, this difference is prevalent among all limitations. Assigning weight to grid points was performed using Analytic Hierarchy Process (AHP) method (Malczewski, 1999; Ying *et al.*, 2007; Sadeghi-Niaraki *et al.*, 2010). In this analysis, population density, moving speed, and angles of view for weighting was considered. In other to recognize distance between points of grid, population criteria was used for possible density population pattern. There are some methods for modeling and large-scale simulation of multi-destination pedestrian crowds. We used semi-automatically extract for the spatio-temporal positions of a low density crowd at close range from an arbitrary observation angle, but without prior knowledge of the pedestrians' heights (Plaue *et al.*, 2011). Most experimental studies of pedestrian dynamics use the classical definition of the density in an area by $D = \frac{N}{\{A\}}$ where N gives the number of pedestrians in the area A of size {A}.

We created density map based on values generated from the area in three timeframes: morning, afternoon and evening, (450 frames) which was used for the final density map (Figure 4). Some spots such as door entrances and elevators area have higher density (high values).

A way to define point values of the density is having every person i produce a density distribution $p_i(x)$, a non-negative function with unit integral $\int p_i(\vec{x}) = 1$. With a given set of trajectories of M persons $\{\vec{x}_1(t), \vec{x}_2(t), \dots, \vec{x}_M(t)\}$ in two dimensions $\vec{x} = (x, y)$ assign an exact position $\vec{x}_i(t_0)$ at time t_0 for each person i. In the next step calculate the Voronoi diagram for these positions and define the density distribution for all persons (Steffen and Seyfried, 2010)

$$P_i(\vec{x}) = \begin{cases} \frac{1}{|A_i|} & : \quad \vec{x} \in A_i \\ 0 & : \quad \text{Otherwise} \end{cases} \tag{1}$$

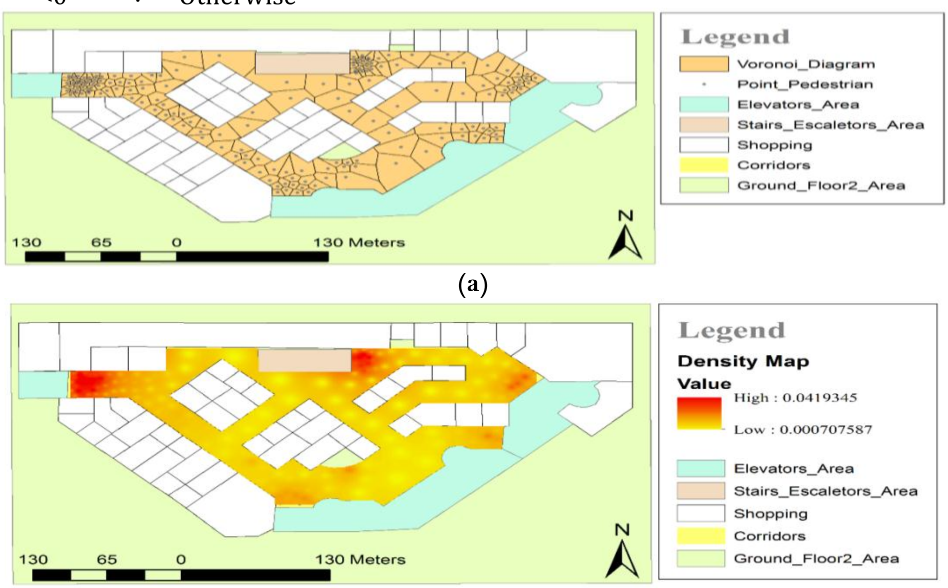
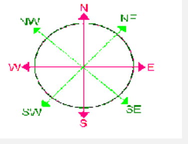


Figure-4. Density map in corridors (a). Voronoi diagram. (b). density population map

After this step, in each grid point one person is being assigned. In direction criteria, directions for each point of grid in 8 major directions have been checked. Following values has been assigned for each part (Table 2). Speed layers has been specified within the range of 1 to 10, and for each part, average speed is assigned from 1 to 10 (Table 3).

Tabl- 2. Direction scale for each layer



Layer name	Direction scale
entrances	5
corridors	8
Exit limitation	5
Exit elevators	3

Table-3. Moving speed scale for each layer

Layer name	Moving speed scale
Entrance of per floor	8
corridor	3
Exit limitation of Escalator	6
Exit elevators	5

Rank sum weights are calculated according to the following formula (Malczewski, 1999) where w_i is the normalized weight for the jth criterion, n is the number of criteria under consideration (k= 1, 2, …, n), and r_i is the rank position of the criterion. Each criterion is weighted $(n - r_i + 1)$ and then normalized by the sum of all weights, that is$\sum(n - r_k + 1)$, final weight values for each layer demonstrated in (Table 4).

$$w_j = \frac{n - r_j + 1}{\sum(n - r_k + 1)} \tag{2}$$

Table-4. Estimating weights based on pairwise comparison

Criterion	Rank	Weight
Density	13	0.433
Moving Speed	9	0.300
Direction	8	0.267
		Sum=1

4.3. Recognition of Suitable Locations for Installing Billboards

In the next step, convenient areas and locations for installing billboards have been recognized. One of the most important parts is facade of shops and corridor walls. Several organizations of the country have prepared some rules for advertising billboards, among these organizations such as Ministry of Roads & Urban Development, Ministry of Culture and Islamic Guidance and Municipality rules. Inside the complex, some rules and limitations have been performed by advertising management (Sadeghi-Niaraki *et al.*, 2013). These rules are about limiting installation billboards and advertising tableaus. So installation of billboard is not possible all over the complex. For example, billboard's height should be at least 2.5m, and its place shouldn't be a disturbance to the public sight inside the complex.

5. USING LOCAL VISIBILITY (LV) MODEL FOR SIMPLIFYING LOCATIONS GEOMETRY

In order to check the amount of visible scope of each grid point to recognize the area of installing billboard, it would require analysis of sight from grid point to the area. But different parts of structural complications causes the difficulty for counting. Thus, decreasing the progress needed to describe the surrounding environment which has been used as a simple linear geometry instead of complex geometry, which has been defined as one billboard for each location. Phenomenon like any place like corridor, stairs, shops and etc. would be a flat surface to local visibility (LV)

(Simon *et al.*, 2006) Like LV geometry model, it is like a panoramic picture that is used for every phenomenon instead of complete 3D model from environment appearance. In this paper, each billboard based on distance, direction and height angles from LV central spots were defined. (Figure 5) shows how counting principle to make a billboard for any kind of phenomenon. Therefore, it illustrates the principle of how an LV's billboard has been computed: The illustration also shows a top-down view of an arbitrary building. First, the visible cross section of the building, seen from the LV's center, is determined. The billboard is computed by intersecting the cross section's center line with the building shape and computing a normal center line.

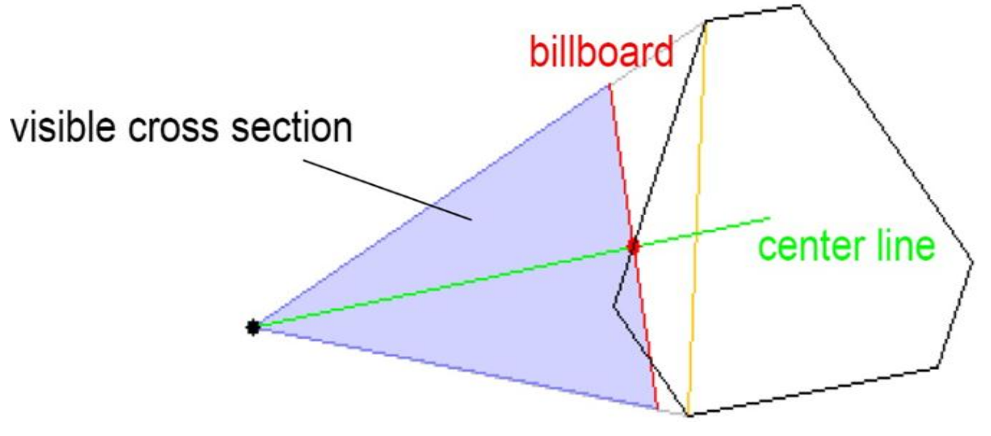


Figure-5. LV's billboard approximation (top-down view)(Simon *et al.*, 2006)

6. 3D VISIBILITY ANALYSIS

The visibility estimation has an important impact in many economical and aesthetic fields, a mixed environment which contains undulating buildings with relief slopes make it challenging for the visibility calculation. By identifying potential of locations for installation of billboard and establishing billboard view for each grid point the amount of sight for each billboard was examined. For this purpose, a GIS approach towards 3D visibility analysis is proposed for measuring visible parts quantitatively in a way that is different from its predecessors, the isovist and the viewshed. We propose a new way of describing the visibility of 3D space by the 3D lines, such that all the visibility events are described. Visibility analysis of each point of the grid to all surrounding billboards of that vertex was created and one bookmark was constructed for each part of the billboard, if the vertex can view. This process was repeated for all points of the grid. By assigning landmarks for all billboard views of all grid points, the value and weight of each landmark was applied according to the weight of the grid that was calculated at the previous stages perform on the land markers (Figure 6).

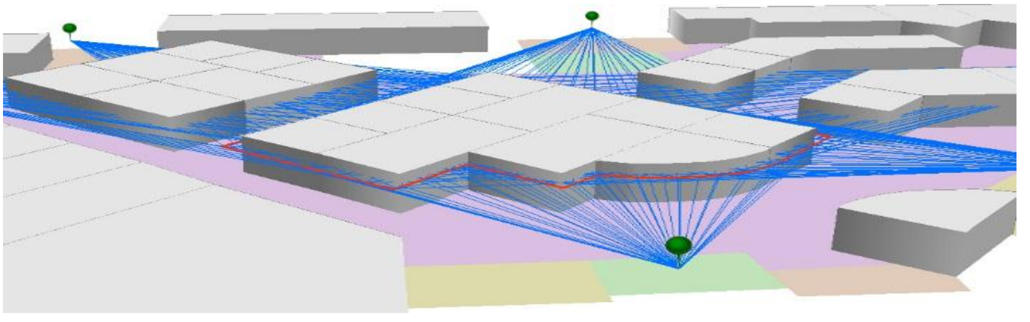


Figure-6. 3D visibility analysis

7. DETERMINING THE BEST LOCATION FOR BILLBOARD INSTALLING

In this step, the total weights of the landmarks that had been considered in the previous steps for each billboard was taken into database. Billboards that have the most weight from grid points will be the best place to install the billboard. There are some platform for advertising such as billboards, stands, wallscape, posters and etc. We ranked all spatial space, shops and corridor walls. Each owner of shops or brands can request for installing advertising signs, and price of sign is based on area rank. This way, will reduce information clutter in shopping center environment, because all location of advertisement is optimized, with maximum visibility of pedestrian and customers (Figure7).

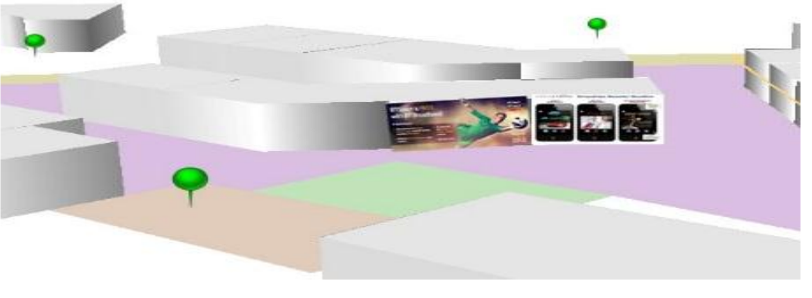


Figure-7. Best locations in 3D space

8. PROVIDING AN ADVERTISING SERVICE-BASED ON AUGMENTED REALITY

In the final stage with the usage of smartphones and using advantages of the Wifi networks, a local and indoor advertising system can be appointed. Based on the user's position and the markers that used in targets the system can send proper and related advertising media such as: texts, videos, hyperlinks and etc, from selected billbords with the best optimal sight. In order to perform the object tracking, markerless augmented reality systems rely in natural features instead of fiducial marks (Kim and Hwang, 2012) Therefore, there are no ambient intrusive markers which are not really part of the environment. Furthermore, markerless augmented reality counts on specialized and robust trackers already available. Techniques developed for online monocular markerless augmented reality systems rely in natural features of the image or object to be tracked, like the edges, corners, or textures (Comport *et al.*, 2006) (Figure 8) illustrates the system architecture of the service to be developed in this work.

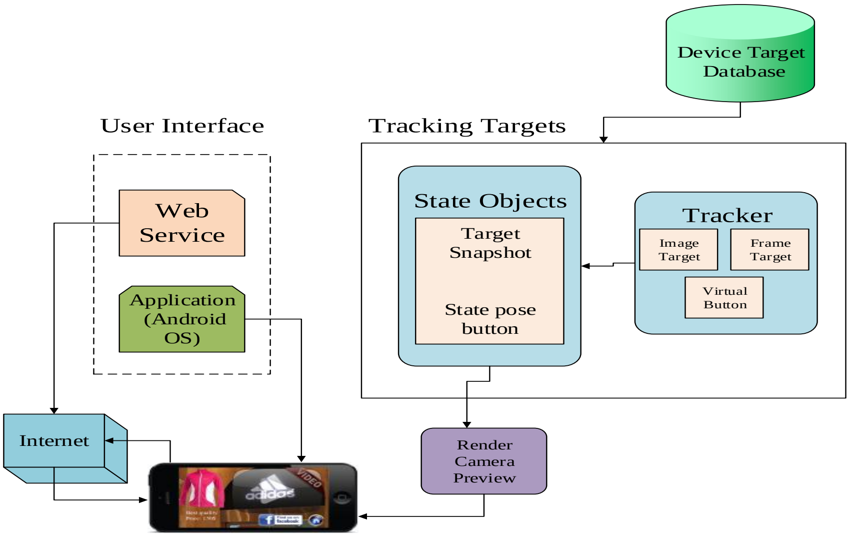
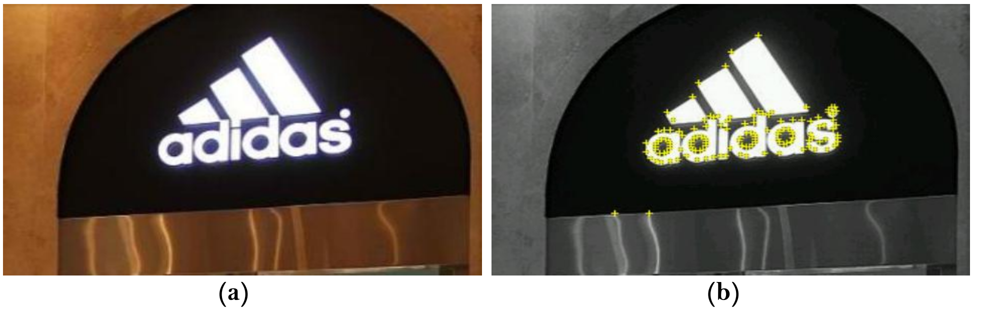


Figure-8. System Architecture

We processed images of targets with natural image tracking algorithm, and provided an image targets database. When the users point to the targets (billboards and advertising signs), device search the database and load related content. Users can pointing their smartphones to the advertisment target and receive augmented reality content (Figure 9). The content can be included in video advertising, text, 3D objects, and other media. Application software developed in Android operating system (OS) that is open source. Our app can be worked online or offline that may be suitable in environment with no internet access.



(a) (b)

(c)

Figure-9. Implementation Augmented Reality app (a). Advertising sign (Target image). (b). Natural feature detection (c). Augmented Reality Content that Using natural feature matching (Markerless Tracking)

9. DISCUSSION AND CONCLUSION

In this research was considered three criterion, density, direction and speed. The final result shows a potential map for pedestrian attention, there is hot spot area in elevators and stairs area. In these areas the pedestrian traffic is maximum, moving speed is minimum and direction of head is optimum. With using visibility analysis all values from potential map assigned to the 3D environment. The result of this model leads to discovery of the best locations for installing indoor based billboards. This brings reducing visual pollution of indoor environment such as shopping centers. On the other hand, in this paper based on the installation's location, billboard prices are determined. Therefore, this introduces a considerable method for advertising cost calculation of indoor advertising area.

Having a distinct formula for determining the price and setting up advertising AR-based services, the ads can be optimized. Augmented Reality services can create attraction of the customers. Using Location Based Services (LBS) such as Augmented Reality make more attention and effectiveness for advertisement billboards and signs. Each company or brand can adopt Augmented Reality services to improve their advertising, better visualization and more products sale. The great appeal of augmented reality, besides its interactivity and ability to engage, is the way in which it extends the reach of the digital realm. Not only does it obscure the lines between branded messaging and useful, life-hack content, but it also obliterates those that separate the physical world from the virtual one.

The future work will focus on to design a method to localize LED billboards as well as to use interactivity feature of the billboards in indoor areas.

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